Using INL Capabilities to Support Meeting the Needs for HALEU

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Using INL Capabilities to Support Meeting the Needs for HALEU

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National Reactor Innovation Center is being established at INL

• Enable the deployment of new nuclear systems by using INL’s unique infrastructure and expertise to resolve the basic R&D challenges confronting the most promising advanced reactor concepts.
  – Fuels and core designs that improve the economics of current operating nuclear power plants
  – Demonstration and first-of-a-kind deployment of new reactor concepts:
    • Advanced small-modular light water reactors
    • Advanced non-light water reactors
    • Microreactors
  – Development of fuel cycle infrastructure

- Xe-100 200 MWt PBR
- ARC-100, MWe
- 150-1500 MWe, Moltex

Inside a NuScale Small Modular Reactor Building
Vision for Advanced Reactor Pipeline

**Demonstrate first <10MW micro-reactor by 2021**
- Resolve advanced reactor issues
- Open new markets for nuclear energy
- Provide a ‘win’ to build positive momentum

**SMR operating by 2026**
- Enable deployment through siting and technical support
- Joint Use Modular Plant leased for federal RDD&D

**Versatile Test Reactor (VTR) operating by 2026**
- Supported by micro-reactor demonstration
- Re-establish leadership in fast-spectrum testing and fuel development capability
- Support non-LWR advanced reactor demonstration

**Non-LWR Advanced Demonstration Reactor by 2030**
- Demonstrate non-LWR technology replacement of US baseload clean power capacity
Advanced reactor fuels are needed for advanced reactors

- Most advanced reactors require fuel/cladding systems that differ from those used in traditional light water reactors
  - Physical form - metallic, mixed oxide, nitride, carbide, dispersion, coated particle, even liquid fuel
  - U-235 enrichment - 5-20%
  - Cladding - composites or coated materials

- There is a need for U enriched between 5 and 20% (commonly referred to as High Assay Low Enrich Uranium [HALEU]) for advanced reactors development
  - Currently there is no domestic capability
INL R&D capabilities are being used to evaluate options for addressing HALEU needs

- Commercial reactor concepts require HALEU for startup cores
- In addition, there are other national missions that require a reliable supply of enriched uranium

### NEI Estimated Annual Commercial Requirements for HALEU to 2030 (MTU/yr)

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<th>Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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https://www.nei.org/resources/letters-filings-comments/nei-letter-perry-need-haleu
INL HALEU R&D Program Objectives

- Evaluate the feasibility of providing an interim supply of HALEU to support fuel-fabrication needs for R&D, and potential demonstration of advanced reactor concepts
- Support the development of HALEU infrastructure to include transportation, fuel fabrication, and advanced reactor testing

https://www.nei.org/resources/letters-filings-comments/nei-letter-perry-need-haleu
HALEU R&D Program Strategy

INL is looking into the feasibility of recovering and down-blending HEU from feedstocks with large ratios of HALEU/HEU that otherwise will be disposed at a cost to tax payers

- Possible feedstocks include end-of-life fuels from diverse irradiation origins
  - EBR-II
  - Naval
  - Others (ATR, orphan irradiated materials, etc.)

- Final HALEU form is determined by fuel specifications and fabrication needs

- Down-blending feedstocks varied and may include:
  - 5% enriched LEU
  - Depleted Uranium
  - Natural Uranium

- Recovery processes (all available/under development at INL) are determined by characteristics of the feedstock and may include:
  - Electrochemical Process
  - Hybrid Process (ZIRCEX)
  - Others
Electrochemical separations process is being applied to EBR-II fuel treatment

Is a batch process that separates and recovers uranium metal from used HEU nuclear fuel and down-blends to HALEU

- **Step 1** – Irradiated HEU EBR-II fuel is prepared and placed into a high temperature molten salt electrorefiner which facilitates separation of U metal from fission products

- **Step 2** – Recovered uranium undergoes vacuum distillation to remove electrorefiner salt and is down-blended to <20% U-235

- **Step 3** – The recovered uranium metal is configured to serve as HALEU feedstock by reheating and casting into low-dose uranium metal ingots

**DOE is evaluating the environmental impact of this process and will be issuing a draft Environmental Assessment for public review and comment later this month**
A hybrid (ZIRCEX) process is also being developed and evaluated

**A three step process that recovers HEU from nuclear fuel and down-blends it to HALEU**

- **Step 1** – ZIRCEX is a dry head-end process to remove cladding (zirconium or aluminum) from nuclear fuel.
- **Step 2** – Uranium is purified from fission products by a very compact, modular solvent extraction system. The fission products are immobilized in glass using a small in-can melt.
- **Step 3** – The uranium is down-blended to <20% U-235 prior to fuel fabrication.
R&D ZIRCEX – Status

- Design, fabrication and installation of a ZIRCEX ¼ pilot plant scale system – completed
- Functionality testing – underway
- Approval to start R&D testing with zirconium expected during October 2018
R&D FY19 – First Quarter Milestones

- Complete staffing for alternatives study – **October 30, 2018**
- Initiate testing of surrogate fuel in ZIRCEX Material Recovery Pilot Plant – **November 2018**
- Begin engineering scoping studies to better understand issues, costs and schedule – **November 2018**
Questions ?